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ABSTRACT

This report resulted from a workshop held in September-October 1983, attended by participants from 15 countries in Asia and the Pacific. Information on the present status of mathematics education in participating countries was collected through questionnaires; it is summarized in terms of background information, time allocation, objectives of mathematics, grade-wise mathematical topics, and instructional methods and aids. In chapter 2, problems and issues are summarized on curriculum content and methodology, learning resources, teacher education, assessment, research, and other pertinent areas. The third chapter identifies innovative experiences related to each of the areas in chapter 2, while chapter 4 offers suggestions for improving mathematics education in each of those areas. Lists of participants are appended. (MNS)

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MATHEMATICS EDUCATION IN ASIA AND THE PACIFIC

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UNESCO-NIER REGIONAL PROGRAMME

MATHEMATICS EDUCATION IN ASIA AND THE PACIFIC

Final Report
of the Regional Design Workshop
on Mathematics Education

Section for Educational Co-operation in Asia
National Institute for Educational Research (NIER)
Tokyo, Japan
December 1983

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INTRODUCTION

Background

It is widely recognized among the participating countries of the Asian Programme of Educational Innovation for Development (APEID) that science and technology are important elements in national development. Mathematics education plays a vital role in the building of thinking ability, scientific understanding, attitudes and skills among the general population which is regarded as a major national thrust in the development of science and technology.

In view of this, the National Institute for Educational Research (NIER) of Japan and Asian Centre of Educational Innovation for Development (ACEID), Unesco, Bangkok jointly convened a Regional Design Workshop on Mathematics Education from 27 September to 20 October 1983 in close collaboration with the Japanese National Commission for Unesco.

Objectives of the Workshop

The objectives of the Workshop were:

(1) To review and analyze the present state of the art of mathematics education;
(2) To identify crucial current issues and problems of mathematics education in the region;
(3) To synthesize innovative experiences and approaches developed in this area; and
(4) To develop strategies for future plans in mathematics education.

Participation

The Workshop was attended by the participants from the following countries: one participant from each of thirteen countries, namely, Australia, Bangladesh, Indonesia, Japan, Malaysia, Nepal, New Zealand, Pakistan, Philippines, Singapore, Socialist Republic of Viet Nam, Sri Lanka and Thailand; and two participants each from China and Republic of Korea. Three resource persons, two participants from RECSAM, one representative from the Unesco Regional Office in Bangkok and five observers also attended the Workshop (For list of the participants see Annex I.).

Inauguration

The Workshop was inaugurated by Dr. Hiroshi Kida, Director General,

National Institute for Educational Research (NIER) of Japan. He extended a warm welcome to all the participants of the Workshop and thanked the Unesco Regional Office for Education in Asia and the Pacific, Bangkok for their collaboration in organizing the Workshop as a true joint venture of ACEID, Unesco and NIER. He also thanked the Japanese National Commission for Unesco and the Ministry of Education, Science and Culture of Japan for their continuing effort in intensifying their support for the regional programme conducted by NIER.

Mr. Hiroyasu Uchida, Division Director for Planning and Coordination, Science and International Affairs Bureau, Ministry of Education, Science and Culture of Japan delivered a welcome address on behalf of the Japanese National Commission for Unesco and the Ministry of Education.

Officers of the Workshop

The Workshop elected the following officers of the Workshop:

Chairperson	Mr. Poon Poh Kong (RECSAM)
Vice-Chairpersons	Mr. R. M. Tilakaratne (Sri Lanka)
	Dr. Kho Tek Hong (Singapore)
Rapporteurs	Mr. Mohd Kamal bin Dasuki (Malaysia)
	Mr. Bevan Werry (New Zealand)

Organization of the Workshop

In preparation for this Workshop, a questionnaire on the present state of mathematics education in the participating countries was prepared by the Secretariat and sent to the participants. Additionally, participants were requested to prepare short papers in relation to problems and issues and innovative approaches and experiences in mathematics education in their own countries. These individual papers as well as the questionnaire responses submitted by the participants provided the basis of discussion at the Workshop, and are summarized in Chapters I, II and III of this report respectively.

The Workshop conducted its business in plenary and group sessions. After common problems and issues were identified at plenary sessions, the participants were divided into three groups and the strategies dealing with six areas of common problems were first discussed by the groups, and then finalized at the plenary sessions (For list of the group members see Annex II.).

During the Workshop, a Regional Conference on Mathematical Education was jointly convened by the International Commission for Mathematical Instruction (ICMI), and the Japan Society of Mathematical Education (JSME), from 10 to 14 October at Komaba Eminence in Tokyo. The general theme of the Conference was mathematics education in and for changing societies, and all participants of this Workshop attended all the programmes of the 1983 ICMI-JSME Regional Conference

on Mathematical Education. A brief synthesis of experiences gained by the participant attending in this conference is given in Annex III.

The participants also had the opportunity of visiting several educational institutions concerned with mathematics and science education in Japan.

Final Report

The draft final report was presented and adopted at the closing session on the last day of the Workshop with modifications to be incorporated in the final report.

Chapter I

PRESENT STATE OF MATHEMATICS EDUCATION IN PARTICIPATING COUNTRIES

Factual information on the state of school mathematics education was collected through questionnaire answers of the Workshop participants and reviewed at the first stage of the Workshop. This chapter presents in summary form a comparative view of place of school mathematics education in the fifteen participating countries — the amount of time allocated to its teaching, its objectives, its content, and some instructional methodologies. To serve as a background, some aspects of the educational systems of the participating countries are first summarized.

Background Information

Chart 1 shows the standard organization of school systems in the fifteen countries together with information regarding the period of compulsory schooling, tuition costs and grades where external examinations are set.

Chart 1 **Standard Organization of School System of Fifteen Countries in Asia and the Pacific**

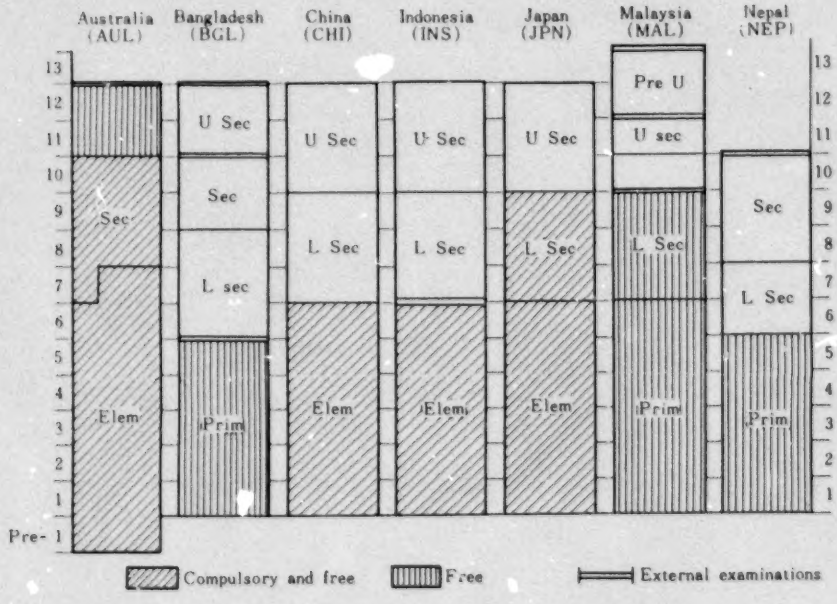
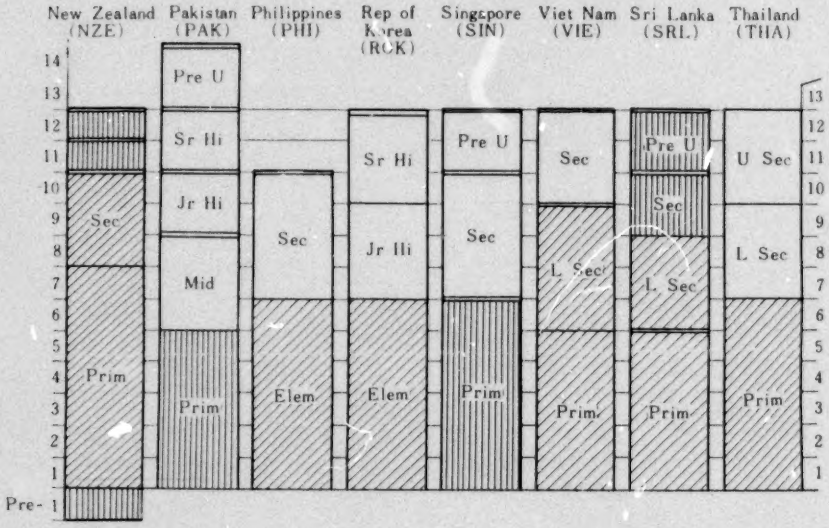


Chart 1 **Standard Organization of School System of Fifteen Countries in Asia and the Pacific (Continued)**



Note: Elem = Elementary School, Prim = Primary School, Sec = Secondary School,
H Sec = Higher Secondary School, L Sec = Lower Secondary School,
U Sec = Upper Secondary School, Pre U = Pre-University,
Jr H = Junior High School, Sr H = Senior High School, Mid = Middle School.

Information on school population, preparation of teaching materials, teacher preparation, promotion procedures, and availability of standardized test are given in the following five tables.

Table 1 **School Population**

Country	Elementary		Secondary	
	P[1]	A[2]	P	A
AUL	12.1	100	7.6	>75[3] 25—50[4]
BGL	13.1	50—75	9.6	<25
CHI	13.8	>75	4.7	50—75
INS	15.9	>75	15.3	50—75
JPN	10.2	100	8.7	>75
MAL	15.6	>75	8.6	>75
NEP	14.9	50—75	12.4	<25
NZE	15.9	100	7.3	>75
PAK	10.2	50—75	0.7	<25[5]
PHI	17.6	50—75	6.1	50—75
ROK	13.9	>75	11.5	>75
SIN	11.6	>75	7.2	>75
VIE	20.7	>75	1.3[6]	50—75[7] 25[8]
SRL	14.2	>75	7.4	>75
THA	12.5	>75	2.4	25—50

Note: 1) $P = \frac{\text{number of children in school}}{\text{total population}} \times 100$

2) $A = \frac{\text{number of children in school}}{\text{number of children of school age}} \times 100$ (rough estimate)

3) For grade 11

4) For grade 12

5) For junior high schools

6) For grade 10

7) For lower secondary schools

8) For upper secondary schools

Table 2 **Preparation of Teaching Materials**

	Curriculum Standard	Year of Last Revision		Student Material		Teacher Guide
		Elem.	Sec.	Elem.	Sec.	
AUL	G[1](State)	78-80	81-	P[2]	P	S[3]
BGD	G	78	80-82	G	G	G
CHI	G	82	82	G	G	G
INS	G	75	75	G	G	G
JPN	G	80	81/82	P/GA[4]	P/GA	G, P
MAL	G	81	78	G	G, P/GA	G, P
NEP	G	81	81	G	G	G[5]
NZE	G	79-83	76-83	G	P	G, P
PAK	G[6]	73/75	76	G[6]	G	G
PHI	G	82-	73	P/GA	P/GA	G, P
ROK	G	82	73	G	G, P/GA	G, P/GA
SIN	G	80	80	P/GA	P/GA	G, P
VIE	G	80	80	G	G	G
SRL	G	80	78	G	G	G
THA	G	78	78	G, P/GA	G, P/GA	G, P/GA

Note: 1) G = by government
2) P = by private agencies
3) S = by school
4) GA = by government approval
5) For grades 4 and 5
6) Provincial government

Table 3 **Teacher Preparation**

	Elementary			Secondary		
	Years of Preservice Training	Credentials	Math Specialization	Years of Preservice Training	Credentials	Math Specialization
AUL	3	B Ed or eqiv.	No	3—4	BD+Dip Ed	Yes
BGD	1	Sec C+TT	No	1	BS	Yes
CHI	3	—	No	2—4	—	No
INS	3	T Sch	No	1—4	*Sarjana*	Yes
JPN	2 or 4	Dip+TC	No	2 or 4	BD+TC	Yes
MAL	3	TC	No	3—5	BD in Ed or BD+Dip	Yes
NEP	2	—	No	4	B Ed or BS	No
NZE	3	T Col Dip	No	3—4	BA/BS+ T Dip	Yes
PAK	1 after gr 10, 12	TC	No	1 after BA/BS	B Ed	Yes
PHI	4	BS in Elem. Ed	No	4	BS in Ed	Yes
ROK	2 or 4	Dip+TC	No	4	BD+TC	Yes
SIN	2	UC in Ed	No	1	U Dip in Ed	Yes
VIE	2	—	No	3—4	—	Yes
SRI	2	—	No	2	—	Yes
THA	2	Dip Ed	No	4	B Ed	Yes

Note: BEd = Bachelor of Education, BS = Bachelor of Science, BD = Bachelor Degree, BA = Bachelor of Arts, Dip Ed = Diploma in Education, Sec C = Secondary School Certificate, TC = Teaching Certificate, T Col Dip = Teacher College Diploma, Dip = Diploma, T Dip = Teaching Diploma, T Sch = Teacher School, TT = Teacher Training, UC = Upper Certificate
U Dip = Upper Diploma
Sarjana is non-degree programme for 1 to 3 years after secondary education

Table 4 **Grade-to-Grade Promotion Procedures**

	AUL	BGD	CHI	INS	JPN	MAL
Automatic	Gr 1-10	—	—	—	Gr 1-9	Gr 1-9
Achievement in all subjects	Gr 11 up yes	yes	yes	yes	Gr 10-12 yes	Gr 10 up yes
Others		Failure in 2 major sub. bars promotion: Math is a major subject.	Failure in 2 major sub. bars promotion: Math is a major subject.			

Table 4 **Grade-to-Grade Promotion Procedures (continued)**

	NEP	NZE	PAK	PHI	ROK	SIN
Automatic	—	Gr 2-10	Prim	—	Gr 1-9	—
Achievement in all subjects	yes	Gr 11 up yes	Secondary yes	yes	Gr 10 up yes	yes

	VIE	SRL	THA
Automatic	—	G 1-10	G 1-6
Achievement in all subjects	yes	G 11 up yes	G 7 up yes

Table 5 **Availability of Standardized Tests**

AUL	BGD	CHI	INS	JPN	MAL	NEP
Australian Council for Educational Research (ACER)	No	No	Centre of Research & Development of Testing	Commercially available	No	No

NZE	PAK	PHI	ROK	SIN	VIE	SRL
New Zealand Council for Educational Research (NZCER)	No	Bureau of Elementary Education (Uuder construction for grds 1 to 6); Centre for Educational Measurement	Korean Educational Development Institute (KEDI)	No	No	No

THA
Department of Curriculum & Instruction

Time Allocation for Mathematics Education in the Schools

The weekly time allotment prevailing in the different countries both for compulsory and elective learning of mathematics was examined, and Table 6 shows the time allocation for compulsory mathematics learning. In the majority of countries that participated in the study, the percentage distribution of mathematics

learning time is higher in the lower grades. Such is the case for Malaysia, Nepal, New Zealand, Philippines and Thailand, where in addition, the amount of time (clock hours) allotted to mathematics also seems to follow a downtrend. Another situation is seen in Sri Lanka and Viet Nam, where both the amount of time and the percentage of time show an uptrend with increasing grade level.

Table 6 **Time Allocation for Compulsory Mathematics Learning**

Age	AUL		BGD		CHI		INS		JPN		MAL		NEP		NZE		PAK	
18					3.8	19%	3.8	14%										
17					3.8	19	4.5	16			3.3	11%						
16					3.8	17	4.5	16			3.3	11						
15	3.5	14%	4.0	15%	4.5	19	3.8	14	3.0	13%	3.3	11	4.0	15%	3.5	14%		
14	3.5	15	4.0	15	4.5	15	3.8	14	3.0	13	3.3	11	4.0	15	3.5	14	4.0	12%
13	3.5	14	4.0	15	4.5	19	3.8	14	3.0	13	3.3	11	4.0	15	3.5	14	4.0	12
12	4.0	16	4.0	15	4.5	17	4.0	17	2.3	10	3.3	11	4.0	15	3.5	14	4.0	14
11	4.0	16	4.0	15	4.5	17	4.0	17	3.8	17	4.0	17	4.0	15	3.5	14	4.0	14
10	4.0	16	3.5	18	4.5	17	4.0	17	3.8	17	4.0	17	4.7	18	3.8	15	4.0	14
9	3.5	14	3.5	18	4.5	18	4.0	18	3.8	17	4.0	17	4.7	18	3.8	15	4.0	15
8	3.5	14	3.5	18	4.5	18	3.0	23	3.8	18	4.0	18	4.5	30	3.8	15	4.0	15
7	3.5	14	3.0	20	4.5	19	3.0	23	3.8	19	4.0	18	4.5	30	3.8	15	4.0	15
6			3.0	20					3.0	16	4.0	18	4.5	30	3.8	15	4.0	15
5															3.8	15	4.0	15

Note: In each column the figure given on the left indicates the standard number of clock hours allocated to mathematics per week in each grade, and that of the right indicates the percentage of the total hours of learning that is allocated to mathematics.

Table 6 **Time Allocation for Compulsory Mathematics Learning (continued)**

Age	PHI		ROK		SIN		VIE		SRL		THA	
18												
17					5.0	14%	3.8	17%				
16	3.0	11%	3.3	11%	5.0	14	4.5	20				
15	3.0	11	5.8	20	3.5	12	3.8	17	4.7	19%		
14	3.0	13	2.6	10	3.5	12	3.8	17	4.7	19	3.3	11%
13	3.0	14	2.6	10	3.5	13	3.8	17	4.7	19	3.3	11
12	3.3	11	3.0	12	3.5	13	3.8	17	4.7	19	4.0	12
11	3.3	11	3.3	12	4.3	17	4.5	20	4.7	19	4.0	13
10	3.3	18	3.3	16	4.3	17	3.3	22	3.3	12	4.0	16
9	3.3	18	2.7	13	3.5	15	3.3	22	3.3	12	4.0	16
8	3.3	18	2.7	15	3.5	15	3.3	22	3.3	12	4.0	16
7	3.3	18	2.7	17	3.0	13	2.7	20	2.7	13	4.0	16
6			2.7	17	3.0	13	1.6	12	1.5	13		
5												

Elective mathematics courses are offered starting at the secondary level, and the time allotment for these courses is shown in the following table.

Table 7 **Time Allocation for Elective Mathematics Learning**

Age	BGD		JPN								MAL		NEP			
		%		%		%		%		%		%		%		%
18																
17	5.0	20							2.3	9						
16	5.0	20	2.3	9	2.3	9	2.3	9	2.3	9	5.3	18				
15	3.0	12											3.3	13	3.3	13
14	3.0	12														
13																

Age	NZE						PAK		PHI					
		%		%		%		%		%		%		%
18							4.0	30						
							8.0	60						
17					4.0	16	4.0	30						
							8.0	60						
16			4.0	16			5.3	20						
15	4.0	16					5.3	20			3.0	11		
14							4.0	12	3.0	11			3.0	11
13							4.0	12						

Age	ROK						SIN		SRL		THA			
		%		%		%		%		%		%		%
18											3.3	11	5.0	17
17	3.0	10	5.4	20	4.1	16	5.0	14	4.3	20	3.3	11	5.0	17
16	3.0	10	5.4	20	4.1	16	5.0	14	4.3	20	3.3	11	5.0	17
15							2.5	9			3.3	11	5.0	17
14							2.5	9						
13														

Place of Mathematics: Its Objectives

Goals of mathematics education are, by and large, indicative of the nature of the society of a country and of the role of the schools in preparing individuals for that society. In this context, the goals may be summarized under five headings: (1) social goals, (2) cultural goals, (3) personal goals, (4) technical goals, and (5) aesthetic goals.*

* Broomes, D., 'Goals of Mathematics for Rural Development' in *Studies in Mathematics Education*, Vol 2, R. Morris ed., UNESCO 1981.

The explicit statements of objectives of mathematics education presented by the different countries were studied for commonalities and for coverage of the above categories.

Common Features

While there is great variation in the manner of expression by the different countries, the essential points do not differ so much. At the elementary level most of the statements include:

(1) Basic knowledge and skills;
(2) Ability to solve problems in daily life; and
(3) Ability for mathematical and/or logical thinking.

Other aspects which some countries refer to in their objectives are:

(4) Utility or necessity of mathematics: Australia, Bangladesh, Thailand;
(5) Cultural value of mathematics: Australia, Indonesia, Pakistan, Thailand;
(6) Links to other studies: Australia, Singapore;
(7) Personal traits, attitudes, interest: Australia, Japan, Malaysia, New Zealand, Singapore, Viet Nam, Thailand;
(8) Preparation for future study: Bangladesh, New Zealand, Viet Nam;
(9) Mathematics as a language or a communication tool: Malaysia, New Zealand; and
(10) Appreciation of mathematics: Indonesia, Singapore.

Secondary level objectives common to most countries are:

(1) Fundamental knowledges and skills;
(2) Ability for problem-solving in daily life situations and/or in other fields of study; and
(3) Ability for mathematical and/or logical thinking.

Other aspects which some countries refer to are:

(4) Cultural aspect, power of mathematics, model builder: Australia, Pakistan, Thailand;
(5) Personal traits, attitude, interest: Indonesia, Japan, Malaysia, Pakistan, Singapore, Viet Nam, Thailand;
(6) Mathematics as language: Australia, Malaysia, Pakistan, Philippines, Korea;
(7) Preparation for future or for other fields: Indonesia, Malaysia, Pakistan, Philippines, Singapore, Viet Nam, Thailand; and
(8) Appreciation of mathematics: Indonesia, Malaysia, Thailand.

Categorization of Objectives

Table 8 which follows gives a view by countries of the categories reflected in the statements of objectives — this is indicated by a tick in the respective rows.

Table 8 **Categories of Objectives of Mathematics Education**

Categories	AUL*	BGD	CHI	INS	JPN	MAL	NEP	NZE	PAK	PHI	ROK	SIN	VIE	SRL	THA
Social	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Cultural	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Personal	X (part)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Technical	X	X	X	X		X	X	X	X	X (sec)	X		X	X	
Aesthetic	X (part)	X	X		X		X	X	X			X	X	X	
Others									X			X		X	

Note: *For the case of Tasmania.

Hidden and Intangible Objectives

Nine countries, that is, Australia, Bangladesh, Indonesia, Japan, Malaysia, Pakistan, Republic of Korea, Singapore and Thailand, reported that one "hidden" objective, although very real, is preparing for examinations. They further stated that the "intangible" objectives such as those related to social, cultural and aesthetic goals are likely to be neglected.

Revision of Objectives

Objectives have changed and will continue to change. Following are major aspects of revision in the recent past or in the near future mentioned by some countries:

(1) Emphasis on mathematical thinking as an agent of modernization: Bangladesh, Japan, Philippines, Korea;

(2) Links to the real world, or problem solving in the real world: Australia, Malaysia, New Zealand, Korea;

(3) Accordance with technological advances, e.g. use of computer: Australia;

(4) Minimal competency or basic skills: Malaysia, Philippines;

(5) Emphasis on non-cognitive aspects; e. g.
social goal: Australia
individualization: Korea
learning how to learn, process of learning: Pakistan

(6) Style of writing objectives;
more precisely: Nepal, Pakistan
more briefly: Japan.

Grade-wise Mathematics Topics in Schools

Various mathematics topics are covered in schools and the tables on the pages from 18 to 25 give a comparative view of the teaching of mathematics topics at different grades among the countries participating in the Workshop. Each topic is taught at different grades and the sequence of taking up the topics under the same category varies slightly among the countries.

There are several topics which are not taught in more than two countries out of 15 participating countries of the Workshop. Such topics are listed below and the names of the countries which do not teach these topics are given within the bracket.

(1) Properties of operation on sets (Japan, Nepal, Sri Lanka)
(2) Non decimal system of numeration (China, Japan, New Zealand, Philippines, Singapore, Viet Nam, Sri Lanka)
(3) Calendar (Bangladesh, Indonesia, Japan)
(4) Traditional system other than SI (Australia, Indonesia, Japan, Malaysia, Nepal, New Zealand, Pakistan, Philippines, Korea, Singapore, Viet Nam, Sri Lanka)
(5) Operations of denominate numbers with two or more units (Indonesia, New Zealand, Pakistan, Sri Lanka)
(6) Estimation of quantities (China, Indonesia, Malaysia, Nepal)
(7) Measured value and error (Indonesia, Nepal, Pakistan)
(8) Translation (Nepal, Philippines, Viet Nam, Thailand)
(9) Tessellation (Bangladesh, China, Indonesia, Nepal, Pakistan, Philippines, Korea, Singapore, Viet Nam, Thailand)
(10) Position in space, three-dimensional notion of coordinate (Indonesia, Nepal, New Zealand, Singapore, Viet Nam, Sri Lanka, Thailand)
(11) Symmetry in space (Japan, Nepal, Philippines, Sri Lanka, Thailand)
(12) Representation of spatial figures in a plane (Indonesia, Nepal, Singapore, Sri Lanka, Thailand)
(13) Notion of probability (China, Nepal, Viet Nam)

The topics which do not appear in the table but which are taught at elementary school are given below with the name of country.

(1) *Soroban* (Japanese abacus): Japan
(2) Keeping household account, Number patterns, Puzzles, Magic squares, Profit and loss, Compound interest: Pakistan
(3) Squares, Square roots, Cubes and cube roots, Average, Rate, Algebraic expression, Simplication and substitution: Singapore
(4) Prime factorization: Bangladesh, Philippines, Thailand

Major mathematical topics taught at secondary level but not included in the following table 9 are given in page 24 onwords with the names of countries. The figures given after the names of country are to show the grades in which the topic

Table 9 **Grade-wise Mathematics Topics**

Topics \ Countries / Streams	AUL		BGD		CHI			INS	JPN
	VIC	TAS	1	2	1	2	3	1	1
SETS									
1. Notion of sets and set-relations	7 - 8	3	1, 3, 6		10	10	10	1 - 4, 7 - 9	10
2. Notion of operations on sets	7 - 8	7	3, 7		10	10	10	1 - 4, 7 - 9	10
3. Symbolic representation of 1 or 2	7 - 8	7	1		10	10	10	1 - 4, 7 - 9	10
4. Properties of operations	7 - 8	9	7				E10	1 - 4, 7 - 9	10
WHOLE NUMBERS									
1. Concept of whole numbers	P - 6	1 - 2	1 - 2		1			1 - 6, 8 - 9	1 - 5
2. Numeration system and place value	3 - 6	3 - 5	3		1 - 3			7 - 9	1 - 4
3. Addition and subtraction	P - 6	2 - 4	1 - 3		1 - 2			1 - 9	1 - 4
4. Multiplication and division	P - 6	3 - 5	2 - 4		1 - 2			3 - 9	2 - 4
5. Properties of operations	P - 6	6 - 7	4 - 5		3			7 - 8	3 - 4
6. Divisors and multiples, GCM and LCM	P - 6	4 - 5	4 - 6		5			7, 9	5, 7
COMMON FRACTIONS									
1. Concept and representation of fractions	3 - 6	3 - 4	2 - 3		4			1 - 8	3 - 6
2. Equivalent relation	6	4 - 5	3 - 4		4			2 - 3, 7 - 9	4 - 5
3. Order relation	7 - 8	4 - 5	3 - 4		4				3 - 5
4. Addition and subtraction of like fractions	6 - 8	4 - 5	3 - 4		4			7 - 9	3 - 4
5. Addtion and subtraction of unlike fractions	6 - 8	5 - 7	4 - 5		4 - 5				5
6. Multiplication and division by whole numbers	3 - 6	5 - 7	4 - 5		5			7 - 9	5
7. Multiplication and division by fractions	7 - 8	5 - 7	5 - 6		4 - 5			3, 7 - 9	6
DECIMAL FRACTIONS									
1. Concept and representation of decimal fractions, place value	3 - 6	5 - 7	4 - 5		4 - 6			7 - 9	3 - 5

MAL	NEP	NZE	PAK	PHI		ROK	SIN			VIE	SRL	THA	
1	1	1	1	1	2	1	1	2	3	1	1	1	2
7 – 8	1	1 –	1 – 3 5 . 9 – 10	I n c		4 – 7			10	E 6 . E 10	1 – 10		9 – 10
7 – 8	1	2 –	1 – 3 9 – 10	i d		5 – 7			10	E 6 . E 10	9 – 10		9 – 10
7 – 8	1	2 –	6 . 9 – 10	e n t a		4 – 7			10	E 6 . E 10			9 – 10
8		6 –	1 – 3 6 – 10	1	7	4 – 7			10	E 10			9 – 10
7	1 – 3	1 –	1 – 2	1 – 6		1 – 4	1 – 3	4 – 5		1 – 6	1 – 10	1 – 6	1 – 7
1 – 4	1 – 3	2 –	1 – 4	1 – 6	7	2 – 4	2 . 3	4 – 5	7	2 – 6	3 – 10	1 – 6	1 – 7
1 – 7	1 – 3	2 –	2 – 3	1 – 6	7	1 – 4	1 – 3	4 – 5		1 – 6	1 – 10	1 – 6	
2 – 7	2 – 4	3 –	2 – 4	1 – 6	7	2 – 4	1 – 3	4 – 5		3 – 6	3 – 10	2 – 6	
7	5	6 –	4 – 7 . 9 – 10	1 – 6	7	E 4 – E 6	2 . 3	6	7	2 – 6	4 – 10		1 – 7
7	6 . 7	3 –	5 – 6 . 9 – 10	4 – 6	7	5 . 6		5	7	6	4 – 10		6 – 7
2 – 3	1 – 2	2 –	1 – 2	1 – 6	7	2 – 3	2 . 3	4 – 6		6	[illegible]	2 – 6	
3 – 7	4	2 –	3 – 4		7	4		4		E 6	[illegible]	2 – 6	4 – 6
3	3	2 –	4 . 9 – 10	3 – 4	7	3	3	4	7	E 6	1 – 10	5 – 6	
4 – 7	3 – 4	3	3 . 5 – 7 . 9 – 10	4	7	4	3		7	6	4 – 10	4 – 6	
5 – 7	5	6	4 . 6 9 – 10	5	7	4		4 . 5	7	6	4 – 10	–	5 – 8
6 – 7	6	6	5 – 6 . 9 – 10	5 – 6	7	4 – 5		4 – 6	7	6	5 – 10	4 – 6	4 – 0
7 – 8	6	8	5 – 6 . 9 – 10	5 – 6	7	5		5 . 6	7	6	5 – 10	6	6 – 8
4 – 7	4 – 5	4 –	4	3 – 6	7	3 – 4		4 – 6	7	5 – 6	3 – 10	2 – 6	4 – 8

Table 9 **Grade-wise Mathematics Topics (continued)**

Topics \ Countries / Streams	AUL		BGD		CHI			INS	JPN
	VIC	TAS	1	2	1	2	3	1	1
2. Relation between fraction and decimal fraction	3 – 6	5 – 7	4 – 6		6			7 – 9	5
3. Addition and subtraction	3 – 6	5 – 7	5 – 6		6			7 – 9	3 – 4
4. Multiplication and division by whole numbers	8	5 – 7	5 – 6		6			6	4
5. Multiplication and division by decimal fractions	6 – 8	5 – 7	6 – 7		6			6	5
NUMBER SYSTEM AND CONCEPT									
1. Non-decimal system of numeration (base 2 or 5, etc.)	7	7	6 – 7					5	
2. Representation on number line	3 – 6	5 – 7	7		6			7 – 9	6
3. Properties of operation	3 – 6	7 – 8	7 – 8		6			7 – 9	
4. Order relation	P – 6	7 – 8	7 – 8		6			7 – 9	6
5. Number sentences using +, −, ×, ÷, =, (and), etc.	3 – 6	5 – 7	4 – 9		4 – 6			6 – 9	6
6. Ratio, proportion, and percentage	8 – 9	7 – 8	6 – 9		6			7 – 9	5 – 6
7. Estimation, approximation and rounding off	3 – 12	6 – 8	8		4			7 – 9	4 – 5
QUANTITIES									
1. Length and distance	P – 12	4 – 7	3 – 6		1 – 3			1 – 9	1 – 3
2. Area	2 – 12	5 – 8	4 – 8		4 – 6			1 – 9	4 – 5
3. Volume and capacity	3 – 12	6 – 8	7 – 8	9, 10	5 – 6			1 – 9	5
4. Angle	6 – 12	6 – 8	7 – 8	9, 10	4			7	4
5. Time	P – 12	3 – 5	4 – 5		3			1 – 6, 8	1 – 3
6. Calendar	P – 12	4 – 5			3				
7. Weight or mass	P – 12	4 – 6	3 – 6		3			2 – 9	3
8. Speed	6 – 12	7 – 8	6 – 7		6			8	5
9. Money	P – 12	3 – 5	4 – 5		1 – 3			8	
MEASUREMENT									
1. Uses of measuring instruments	P – 12	2 –	3 – 6		5			1 – 9	2 – 3
2. Metric system, or SI	3 – 12	3 –	5 – 7		2			7 – 9	2 – 6

MAL	NEP	NZE	PAK	PHI		ROK	SIN			VIE	SRL	THA	
1	1	1	1	1	2	1	1	2	3	1	1	1	2
4 – 7	4 – 5	4 –	4 , 5 , 7 , 9 – 10	4 – 6	7	4		4 – 6	7	6	3 – 10	6	5 – 8
5 – 7	4 – 7	4 –	4 – 7 , 9 – 10	4 – 6	7	3 – 4		4 – 5	7	5 – 6	3 – 10	6	5 – 8
5 – 7	5 – 6	5 –	4 – 7 , 9 – 10	5 – 6	7	4 – 5		4 – 5	7	5 – 6	4 – 10	6	6 – 8
7	5 – 6	6 –	5 – 7 , 9 – 10	5 – 6	7	5 – 6		6	7	5 – 6	5 – 10		6 – 8
8 – 9	2 , 3		8 – 10			7						1 – 6	8
7	4 – 6	1 –	5 , 7 , 9 – 10	1 – 6	7 – 8	1 – 4 6 , 7			7	2 – 12	6 – 10	1 – 6	7 – 11
8 – 9	3 – 7	8 –	4 – 5 , 9 – 10	3 – 6	7	E 3			7	2 – 9	6 – 10	1 – 6	7 – 11
7	2 – 3	1 –	9 – 10	1 – 6	7	3 – 4			7		6 – 10	1 – 6	7 – 11
1 – 7	4	1 –	2	1 – 6	7 – 8	2 – 6	1 – 3	4 – 6	7	2 – 5	6 – 10	2 – 6	1 – 11
6 – 8 , 11	6	6 –	6 – 10	4 – 6	7 , 9	5 – 6		5 – 6	7	6 – 7	6 – 10	4 – 6	4 – 8
2 – 8		3 –		4 – 6	7 , 9	4 – 7		4 – 6	7	6 – 7	6 – 10	4 – 6	6 – 8
2 – 8	1 – 5	1 –	3 – 4	1 – 4	7 , 9	1 – 3	1 – 3	3 – 5	7	1 – 4	1 – 10	1 – 6	1 – 7
6 – 8	6 – 7	4 –	4 – 6 , 9 – 10	2 – 5	7 , 9	4 – 5		4 – 6	7	5	1 – 10	5 – 6	4 – 9
5 – 8	6 – 7	5 –	5 – 6 , 9 – 10	5 – 6	7 , 9	5 – 6	2 – 3	4 – 6	7	5	1 – 10	5 – 6	5 – 9
7	1 – 5	3 –	3	5 – 6	9	3 – 4 , 7		4 – 6	7	2 – 4	2 – 10	3 – 6	3 – 9
2*	1 – 5	2 –	1 , 3	1 – 4	7	2 – 4	2 – 3	4 – 5		2 – 5	2 – 10	2 – 4	
3	1 – 5	2 –	3		7	E 6		4		2	2 – 10	1 – 4	
4 – 6	1 – 5	3 –		1 – 3	7	3 – 5	1 – 3	4 – 5	7	2 – 4	2 – 10	1 – 6	
8	6 – 7	8 –	9 – 10		7 , 10	6		5 – 6	7	5	2 – 10	4 – 6	11
2 – 6	1 – 5	1 –	9 – 10	1 – 3	7	E 3	2 – 3	4 – 6	7	2	2 – 10	1 – 6	
2 – 8	6 , 7	2 –	6 – 8	2 – 6	7	E 3 – E 5	1 – 3			1 – 6	6 – 10	2 – 4	
2*	3 – 5	2 –	3 , 9 – 10	2 – 6	7	E 6	1 – 3	4 – 6	7	1 – 6	3 – 10	1 – 6	

Table 9 **Grade-wise Mathematics Topics (continued)**

Topics \ Countries / Streams	AUL		BGD		CHI			INS	JPN
	VIC	TAS	1	2	1	2	3	1	1
3. Traditional system other than SI			3 – 5		1 – 6				
4. Operations of denominate numbers with 2 or more units	8 – 12		6 – 9		4				2 – 3
5. Using formulae for area or volume	7 – 12	6 – 8	4 – 7		4 – 6			7	4 – 5
6. Estimation of quantities	P – 12	4 –	6 – 7						5
7. Measured value and error	3 – 12	9	8 – 9		5				5, 7
PLANE GEOMETRIC FIGURES									
1. Straight line and angle	7	6 – 8	5 – 6		8			6, 9	2 – 3
2. Parallel and perpendicular	7	6 – 8	6 – 8		8			3, 5 – 6, 8	4
3. Simple basic figures and their properties	7 – 8	6 – 9	6 – 10		8			6, 9	2 – 5
4. Drawing geometric figures	P – 12	6 – 9	7 – 9	9 – 10	8			3,	5 – 7
5. Congruence	9	8 – 9	8 – 9	9 – 10	8			9	5, 8
6. Similarity, or scale drawing	9	8 – 9	8 – 9	9 – 10	9			9	6, 8
7. Symmetry	3 – 9	6 – 9	9 – 10	9 – 10	8			6, 7	6
8. Translation	3 – 9	6 – 9	9 – 10	9 – 10	8			6, 8	5, 8
9. Tessellation	3 – 9	6 – 9							2
10. Mensuration of perimeter and/or area	6 – 8	6 – 8	9 – 10	9 – 10	8 – 9			6, 8	4 – 5, 7
11. Position and notion of coordinate	4 – 8	5 – 8	9 – 10	9 – 10	7			7	2, 7
SPATIAL GEOMETRIC FIGURES									
1. Planes and lines in space	7 – 8	7 – 9	9 – 12	9 – 10	10	10	10	2 – 6	4
2. Parallel and perpendicular	7 – 8	7 – 9	9 – 12	9 – 10	10	10	10	2 – 6	4
3. Vertical and horizontal	3 – 8	7 – 9	9 – 12	9 – 10	10	10	10	2 – 6	4
4. Position in space, notion of coordinate	9 – 12	8 – 9	9 – 12	9 – 10	10	10	10		4, 7
5. Simple basic spatial figures and their properties	3 – 12	8 – 10	11 – 12	9 – 10	10	10	10	3 – 6	4, 6
6. Symmetry in space	3 – 12	9 – 10	11 – 12		10	10	10	7	7
7. Representation of spatial figures in a plane	7 – 8	8 – 10	11 – 12		10	10	10		6 – 7
STATISTICS AND GRAPHS									
1. Elements of statistics	4 – 11	8	7					4 – 8	3 – 6, 8

MAL	NEP	NZE	PAK	PHI		ROK	SIN			VIE	SRL	THA	
1	1	1	1	1	2	1	1	2	3	1	1	1	2
7	5, 6			6	7, 9	3 – 4		4, 5		3 – 6			3 – 4 4
6 – 7	6, 7	7 –	4, 6 – 10	4 – 6	7, 9	3 – 6		4 – 6	7 – 8	5 – 6	6 – 10	4 – 6	4 – 9
		2 –	1 – 2		7, 9	6 – 7	E 3	E 4 – 5	7	7, 10	6 – 10		1 – 4
10		5 –			7	5 – 7			S 1	7, 10	6 – 10	5 – 6	1 – 4
7	1 – 5	2 –	3 – 4, 6 – 7, 9 – 10	4	7, 9	3 – 4		5, 6	7	7	6 – 10	3 – 6	3 – 8
7	6 – 7	4 –	5 – 7	4	7, 9	4 – 5		4 – 6	7	7	6 – 10	4 – 6	4 – 8
4, 7 – 9	4 – 6	1 –	2 – 3, 5 – 7	2 – 3	7, 9	3 – 5		4 – 6	7	7, 10	1 – 10	5 – 6	2 – 8
7 – 9	4 – 6	2 –	6 – 7, 9 – 10	1 – 6	7	4 – 6			7	7, 10	1 – 10	2 – 6	2 – 8
8	6 – 7	4 –	9 – 10	4 – 6	9	5 – 7			8	7	6 – 10		6, 8
8	6 – 7	7 –	9 – 10	5 – 6	9	5 – 6, 8			7 – 8	9 – 10	3 – 10		6 – 8
7 – 9	4	2 –	9 – 10	1 – 2	9	5			8		1 – 10		3 – 6
9		8 –	9 – 10			11 – 12			E 8		6 – 10		
9		2 –									6 – 10		
7	5, 6	6 –	6 – 10	4 – 6	7, 9	E 4		4 – 6	7	4 – 5 10 – 11	1 – 10		5 – 9
6 – 7	6, 7	3 –	8 – 10	6	8 – 10	5 – 8		5, 6	8	7 – 10	6 – 10		6 – 10
7		3 –	6 – 7, 9 – 10	4 – 6	9	7			9	11		3 – 6	
7	5, 6	4 –	5, 9 – 10	4	9	7			7	11	6 – 10	4 – 6	
7	5, 6	6 –	4	5 – 6	9	7			8	11	6 – 10	4	
7			9 – 10	5 – 6		5 – 7, 9							
7		3 –	6 – 7, 9 – 10	5 – 6	9	7				11 – 12	1 – 10		2 – 6
7		3 –	8 – 10			6 – 7			8	11		6	
7		8 –	6 – 7, 9 – 10	5 – 6		6 – 7				11			
7 – 10		3 –	7, 9 – 12		7, 9	3 – 8			9	E 6, E 9	3 – 10	4 – 6	3 – 9, 12

Table 9 **Grade-wise Mathematics Topics (continued)**

Topics \ Countries / Streams	AUL		BGD		CHI			INS	JPN
	VIC	TAS	1	2	1	2	3	1	1
2. Notion of probability	4－12	9	7					4－6, 8	6, 9
3. Bar-graph, linegraph, pi-graph, etc. (various statistical graphs)	4－12	8	7－9		6			4－6, 8	3－5
INTRODUCTORY ALGEBRA									
1. Positive and negative numbers	7－8	7	7		7			8－12	7
2. Use of variable	9－12	7	7－8		9			9－12	7
3. Simple equations	7－8	7	7－9	9－10	7			9－12	7
4. Notion of function	9－12	8		9－10	9			11－12	7
5. Simple functional graphs	9－12	8－9		9－10	9			11－12	7

Note: 1) The numbers in the columns indicate the grade or grades in which the topic is taught.
2) Topics attached to 'E' mean that they are found in the curriculum for experimental purpose.
3) Blank columns should be interpreted that the corresponding topics are not included both in the elementary and secondary mathematics curriculum.
4) In Australia, topics attached to 'P' mean that they are found in the perparatory level.

is taught.

Sets and Logic

Logic: Indonesia; Japan 10-12; New Zealand; Pakistan 8-9; Thailand 9-10

Number

Square and square root, cube and cube root: Bangladesh 8 (not cube root); Japan 11; New Zealand 8-9; Pakistan 8-10; Thailand 9 (not cube root)

Common logarithm: Bangladesh 9-10; Japan 11; Malaysia 9; Thailand 11

Prime factorization: Bangladesh 5-7; New Zealand 8; Republic of Korea 7; Thailand 7

Complex numbers: Australia 12; China; Japan 10; Newzealand 12; Thailand 11

Algebra

Algebraic expressions: New Zealand 8-11; Pakistan 8-10; Thailand 7-8

Factoring of polynomials: Bangladesh 8-10; Japan 10; New Zealand 9-11; Pakistan 9; Republic of Korea 8-9; Thailand 9

Binomial theorem: Australia 12; China; Japan 11; New Zealand 12; Thailand 12

Linear inequalities: Australia 10; Bangladesh 8-10; Japan 10; New Zealand 9-10; Singapore; Thailand 8

System of equations: Australia 10; China; Japan 10; Thailand 9

MAL	NEP	NZE	PAK	PHI		ROK	SIN			VIE	SRL	THA	
1	1	1	1	1	2	1	1	2	3	1	1	1	2
10—11		7—	11—12		9—10	6, 9, 11			10		6—10	4—6	9-12
6—11	5—7	3—	4—5, 7	4—6	7, 9	3—6	1—3	4—6	9	E 6, E 9	1—10	4—6	3—9, 12
7	5—6	7—	4, 7		7—8	6			7	7	6—10	1—6	7—8
7—11	5—7	6—	6—9, 9—10		7—8	7			7	7—12	6—10	2—6	6—8
7—9	4—7	6—	8—10	4—6	7—8	7			7	7—12	6—10	5—6	6—8
8	6—7	6—	9—10	4—6	8, 10	7, 10			8	8—12	9—10	6	7—10
8	6—7	6—	9—12	5—6	10	7—12			8	8—12	9—10	4—6	7—11

Quadratic equations: Australia 10; Bangladesh 11-12; Japan 10; New Zealand 9-11; Republic of Korea 8-9; Thailand 9

Quadratic inequalities: Australia 10; Japan 10; New Zealand 11-12; Republic of Korea 8-9

Graphical solution of equation: Bangladesh 9-10; New Zealand 9-11; Singapore

Matrices: Australia 11; Indonesia; Japan 11; Malaysia 10; New Zealand 10-11; Pakistan 9-10; Singapore; Thailand 12

Algebraic structure: New Zealand 10-11

Linear programming: Australia 11

Numerical Mathematics

Flowcharts: Japan 11; New Zealand 8

Use of computers in solving problems: Japan 11

Solution of equations, numerical differentiation, integration: New Zealand 12

Analysis

Arithmetic sequences and geometrical sequences: Bangladesh 9-10; Japan 11; New Zealand 11; Thailand 11

Limit of infinite sequences: China; Japan 12; New Zealand 12; Thailand 11

Quadratic functions: Australia 10; Japan 10; New Zealand 9-11; Republic

of Korea 8-9; Thailand 10

Other algebraic functions: Australia 11; China; Japan 11; New Zealand 10-12; Thailand 10

Trigonometric functions: Australia 11; Bangladesh 11-12; China; Japan 11; New Zealand 9-11; Thailand 9 & 11

Exponential functions: Australia 12; China; Japan 11; New Zealand 12; Thailand 11

Logarithmic functions: China; Japan 12; New Zealand 12; Thailand 11

Inverse trigonometric functions: China; New Zealand 11-12; Thailand 11

Differentiation: Australia 12; Bangladesh 11-12; China; Japan 11-12; New Zealand 11-12; Thailand 11

Integration: Australia 12; Bangladesh 11-12; China; Japan 11-12; New Zealand 11-12

Geometry

Plane deductive geometry: Pakistan 8-10; Thailand 9

Locus: Australia 10; Japan 10-11; Malaysia 8; New Zealand 9

Transformations: Australia; Japan 10-11; Malaysia 8; New Zealand 8-11

Solid geometry: Japan 11; Pakistan 8-10

Trigonometric ratio: Australia 9-10; Bangladesh 9-10; Indonesia; Japan 10; New Zealand 9-11; Pakistan 9-10; Republic of Korea 9; Singapore; Thailand 9-11

Navigation: Malaysia 11; Singapore

2-dimensional coordinate geometry: Australia 8; China; Japan 10-11; New Zealand 9-12; Thailand 10

Vector: Australia 11; Japan 11; Malaysia 9-10; New Zealand 10-12; Pakistan 9-10; Singapore; Thailand 11

Element of topology: Republic of Korea 7-9

Probability and Statistics

Permutation and combination: Australia 11; China; Japan 12; New Zealand 12; Thailand 12

Statistics: Japan; New Zealand 9-12; Republic of Korea 9; Thailand 12

Instructional Methods and Aids in Mathematics Teaching

This section has a bearing on how a teacher teaches and the materials used.

Instructional Aids

Mathematics textbooks or some other printed materials are provided in all countries. In Australia, no particular textbook is required. No textbook is used in the lower grades in a few countries; instead activities based on structured materials are used in Australia (to grade 2), workbooks are used in Malaysia (to grade 3), and a teacher's handbook is used in New Zealand (grade 1).

Concrete materials may be familiar things from daily life or from the environment (e.g. toys, games) or may be structured materials purposefully constructed for mathematics teaching (e.g. geoboards, Diene's blocks). The following are some games mentioned as usable for mathematics lessons:

Playing stone: Australia;

Treasure finding: Bangladesh;

Wanage (quoits), *origami* (paper-folding), *saikoro* (dice): Japan;

Luksong tinik (jump the spine): the Philippines;

Shuttlecock, tag games: Republic of Korea;

Domino-type games: Singapore;

Rhee rhee kao sarn (Thai children folksong about rice): Thailand.

Other countries which reported the use of environmental materials are New Zealand and Pakistan.

Structured materials are used in the schools of Australia, China, Japan, New Zealand, Singapore and Thailand. In Malaysia, Nepal, Pakistan and Republic of Korea, structured materials are also used but not so extensively.

For both environmental materials/activities and structured materials, a few countries mentioned decreasing use with increasing grade level. It is likely that such is the case in many of the other countries.

Regarding the abacus, instructions on its use are given in Bangladesh (grades 1 to 3), China (grade 4), Japan (grade 3), and Republic of Korea (grade 6). The use of an improvised abacus as a model for place value —— a system of beads on rods —— was mentioned in the reports of Malaysia, New Zealand, the Philippines and Thailand.

While the calculator has become very much a part of daily use in many countries, the extent of its use in schools is not as universal as can be seen from the following comments:

Calculators are not used because a majority of the children lack access to them: Indonesia, Malaysia, Nepal, Pakistan, the Philippines, Republic of Korea, Socialist Republic of Viet Nam and Thailand;

Children are not allowed to use calculator in schools: Bangladesh; China;

Calculators are introduced into schools: Australia (grade 10 up), Japan (grade 5 up), New Zealand, Singapore (grade 10 up).

Teaching Methods

Two methods of facilitating learning are considered: the giving of homework, and the activity approach.

In all of the countries, homework is assigned with the objectives of reviewing ideas learned, reinforcing skills, or, at the end of a unit for consolidating learning. In some cases, homework is given to develop thinking skill, e.g. in the Republic of Korea. Some qualified statements on the frequency or length of homework were given:

Homework is seldom given at the elementary level: Australia;

Homework is seldom given in elementary schools in the rural areas since children are expected to help in house or farm work: the Philippines;

Homework is not assigned daily in some places in order to lessen the teacher's burden of work, especially since classes tend to be large: Pakistan.

Activity approaches are in evidence in Australia, China, Japan, Malaysia, Nepal, New Zealand, the Philippines, Republic of Korea, Singapore, Socialist Republic of Viet Nam and Thailand, but in most of these countries only in the lower grades or in urban areas. Other countries such as Bangladesh, Indonesia and Pakistan regard an activity approach as desirable although not implemented. Some reasons presented for non implementation or implementation to a small extent are as follows:

Large classes, high student-to-teacher ratio: Bangladesh, Pakistan, Republic of Korea;

Lack of qualified or motivated teachers: Bangladesh, Indonesia, Malaysia, Nepal;

Need for more time for activity approach (in comparison to traditional chalk-and-talk method), which works against the need to cover the syllabus: Singapore.

Special Programmes for Slow Learners or Gifted Students

In Australia, China, Japan, New Zealand, Republic of Korea, Singapore and Thailand, special programmes for remedial work outside the usual class time exist, and the next set of remarks relates to them.

Special teachers are employed to undertake such work: Australia (some states);

Remedial work is undertaken as part and parcel of the teaching-learning activity: Malaysia, the Philippines;

Special classes are created specifically to prepare for certificate examinations when the time for such examinations draws near: Bangladesh; Pakistan.

Finally, with regards to special programmes for the mathematically gifted, such programmes exist in the countries of Australia, China and the Philippines, but in Australia, less resources are allocated for programmes for the gifted than for remedial programmes. In Singapore, a pilot project for the gifted is planned for 1984 in two primary and two secondary schools for special programmes. Special sections in some schools of the Philippines or special schools in some regions, notably the subsidized Philippine Science High School are reserved for gifted students.

Chapter II

PROBLEMS AND ISSUES

This chapter summarizes problems and issues identified by countries in their position papers presented to the Workshop. These problems and issues were discussed further by participants, and related suggestions and strategies toward improving school mathematics teaching and learning are recorded in Chapter IV.

Curriculum Content and Methodology

During the last two decades, most countries reviewed the mathematics curricula of their schools and developed new curricula to replace the existing ones, particularly for the elementary schools. Elements of "new" or "modern" mathematics were included in these new curricula in many countries. For example, set language and activities were introduced to explain mathematical concepts and skills, and the laws of arithmetic and number bases were included to aid understanding of number work. Statistics and transformation geometry are further examples of topics found in many of the new curricula. Updating of the curriculum content was to be complemented by changes in teaching method in order to encourage the learning of mathematics through understanding rather than by rote. Concrete experiences and activity-based learning were to be prominent in this method.

More recently, many countries have further reviewed their mathematics curricula in the light of experience in teaching this material. In some cases the teaching of mathematics has not been found to be generally as effective as intended. Attempts to implement these changes have been accompanied by problems ranging from providing adequate teacher training, both pre- and in-service, on a large scale, the revision of text materials, and the supply of non-print resources, to adjusting the approach to meet the needs of a greatly increased ability range. In addition, many of the strategies of implementation were adopted with minimal modification by other countries where teacher preparation, school organization and societal expectation were significantly different. The attitude of many teachers towards change was a further inhibiting factor.

Despite these considerable problems of adjustment which continue to require attention, there is a general commitment to retain the positive features which motivated the changes in the first place, and to continue to adapt approaches to local needs and new challenges. A major problem for most is to anticipate future directions of curriculum change.

Learning Resources

Most countries have developed student texts to match their recent curriculum changes. In addition to such texts, attention has been given to the provision of teacher guides. Generally these materials are produced by government authorities. Three particular kinds of problem are being encountered.

(1) Providing contexts that are balanced between urban and rural;
(2) Including more ideas which might promote the deliberation; and
(3) Development of problem solving.

Despite the increased attention given in teacher training to the use of concrete materials, it is acknowledged that problems still exist in ensuring their supply and in their use even when present in the school.

Problems also remain in acquainting teachers with the effective classroom use of resources in non-print form. Class sizes of more than 40 students are common in some countries. The logistics of managing classes using concrete materials on an individual or small group basis are demanding, and are not always effectively demonstrated.

Resources for teacher development have also received attention and several countries have reported the effective use of television and radio. On the other hand, no such claim has been made for the use of these media for student learning.

The potential roles of calculators and computers, both as aids to learning mathematics, and as agents to modify the curriculum of the future is of some concern. There is, however, wide variation in the commitment to investigating ways of making effective use of these technologies in the mathematics curriculum. This commitment is directly related to their availability to schools.

Teacher Education

Some countries still have problems with the supply of qualified teachers, particularly in rural schools. In these countries the salaries are inadequate to attract potential graduates, and there are problems of insufficient esteem being accorded to teachers.

In countries where an extreme shortage in the past had been met by employing teachers with inadequate backgrounds who may have been pushed through short term courses, there now remains the problem of how to sufficiently upgrade their qualifications. In these countries the main focus has shifted from pre-

service to in-service needs.

Some problems arise when teachers in training are taught mathematics and mathematics teaching methodology by different lecturers. There is the likelihood that they will learn mathematics in a way which is at variance with the methods being advocated during their methodology classes.

It is anticipated that as computers become more established in the curriculum, particularly in secondary schools, there may be a movement of some of the young, talented mathematics teachers into computer studies and managing the system of computers in the school. Although the total number may not be great, many of them may be the potential leaders in innovation and inspiration in mathematics.

Although considerable advances have been made in the provision of pre-service teacher training in all countries, there remain problems both in the provision of such training in countries where extensive recruiting is anticipated, and in improving the quality of the training. In some countries, it is still common for prospective elementary teachers to receive their training in mathematics and its teaching from lecturers who have never taught school children of elementary age.

There continues to be general concern about finding ways to follow up the pre-service emphasis on activity-based learning, which may otherwise not last long once the teachers commence full-time duty, and observe that what has been promoted in pre-service courses is not commonly practised by their colleagues.

Assessment

Some countries expressed concern about the way that external and formal norm-referenced examinations distort and constrain the mathematics curriculum of schools.

Easily measurable computational and manipulative skills tend to predominate in paper and pencil tests, to the exclusion of higher ability cognitive processes. Teaching methods reflect this tendency and emphasize short-term recall and convergent processes, rather than exploratory open-ended and practical situations. The important and over-riding aim for students and teachers alike becomes the passing of the examination and the stated objectives of the course are ignored. These attitudes towards mathematics programmes are unfortunately reinforced by parents and the community. The effects are greater if the examination is used for the purpose of selection for higher education.

A related concern refers to the use of percentage marks and the consequent in-built failure for half the population. The reliability of the examinations and the assessment procedures are further problems in some cases.

Research

Research into various aspects of mathematics education is felt to be necessary

and important in improving the teaching and learning of mathematics. Research results could provide useful information not only for curriculum development, but for other areas of mathematics education also, such as for teacher education in mathematics and for improving mathematics teaching in the classroom itself. However, research work pertaining to mathematics education proves wanting in many countries and there is generally a lack of relevant research expertise in these countries. Even though there has been progress made in research activities in a number of other countries, there are the problems in translating the research findings to effect necessary changes in mathematics education.

Some Other Pertinent Areas

It is recognized that mathematics has a language of its own, and that this language plays an important role in the teaching and learning of mathematics. Mathematical terminologies and symbols, on the other hand, do not occur naturally in the daily life of children. Some languages are not yet sufficiently developed to include the vocabulary to express a full range of mathematical ideas. All these pose difficulties to children in learning mathematics. There is also a problem when children can not properly follow the teaching of the subject in the medium of instruction used when this is not the mother tongue. Such a situation adds a further dimension to the difficulties in the teaching and learning of the subject.

Class sizes are generally large in many countries. While it is recognized that such large classes contain students who are gifted in the subject as well as those slow in learning it, due attention can often not be given to these special students. Even if the number of students in each category is small in a class, the total number of such students is considerable, and it is most important for their needs to be met. There is thus the need to make further provision for the mathematically talented, while those slow in following the subject can also be given such assistance as is necessary to enable them to progress in the learning of the subject. If education is to enable children to progress to the best of their ability, then such provisions must be deemed necessary for both the gifted and the slow-learner to benefit fully from the education provided to them.

Chapter III

INNOVATIVE EXPERIENCES

In preparing a paper for the Workshop, participants were requested to identify and describe briefly any innovative experiences in mathematics education which had been implemented recently, or which were in the process of development in their countries. This chapter summarizes the innovative experiences reported.

Curriculum Content and Methodology

Most countries referred to curriculum content changes and noted topics which had been introduced in these revisions. In general, these developments involved modernization, updating and revising existing curricula to take account of changing needs and emphases reflected in the objectives for teaching mathematics in the country.

Activities in connection with the promotion of problem-solving at various levels are noted in Australia, and the development of new approaches aimed at promoting and evaluating higher thinking processes in Japan. In Bangladesh there is a sustained effort to encourage teachers to teach for understanding. A project on mathematical modelling exists in Australia.

Close integration of mathematics with science in elementary school is reported in the Republic of Korea. In Thailand, work is being done to relate classroom mathematics more closely to daily life requirements.

A set of Minimum Learning Competencies has been prepared in the Philippines to be used in conjunction with a goal-oriented instructional model. In China, there is experimentation with a Knowledge Structure Unit Method based on a careful analysis and sequencing of teaching content.

Improvements in decision-making methodologies related to curriculum change are observed in the Philippines, while in New Zealand there is lay involvement in curriculum development and an effort to provide greater continuity of learning from elementary to secondary school. A Computer Assisted Instruction project for supplementing mathematics programmes to help improve elementary school pupils' performance is in a planning phase in Singapore.

Professional associations of mathematics teachers are providing a forum for discussion about mathematics curricula in Japan and the Philippines. In these countries, there is also a deliberate move to evaluate mathematics curricula.

Learning Resources

Preparation and production of new manuals and guides for teachers are reported in Australia, Bangladesh, Indonesia, Japan, Malaysia, Nepal, New Zealand, Pakistan, the Philippines, Singapore and Thailand. In Malaysia and Pakistan, kits of apparatus and teaching aids have been prepared and made available to schools. Other teacher support materials and a journal for teachers have been produced by RECSAM.

Teacher Education

Emphasis is being given to teacher training in many countries. In the Philippines, Singapore and Socialist Republic of Viet Nam, there are programmes to upgrade the qualifications of teachers in schools. Radio is used for this purpose in Nepal, and in Indonesia trials of distance learning method of teacher training are in progress. Work is being done in Australia to develop a model for instruction in mathematics, leading to pre and in-service programme with teachers. Bangladesh is involved with training of teacher-educators. In Malaysia, key teachers are identified to provide guidance to others and a formal advisory service has been introduced.

Assessment

Criterion-referenced and mastery learning approaches are reported in New Zealand, the Philippines and Singapore. Mid- and end-of-year achievement tests are being experimented with in the Philippines. Item banks of mathematics questions have been produced in Bangladesh and New Zealand. In New Zealand, there is also experimentation with forms of testing alternative to external examinations.

Research

A variety of research is being conducted in most countries. RECSAM is involved in investigations of children's understanding of mathematical concepts. In Australia, the mathematics used in the work place by people in their first job is being studied. Research on teaching strategies and on the medium of instruction which is most effective in mathematics education is being undertaken in the Philippines, particularly in schools in Manila. Research findings on a variety of topics are shared at regular conferences of professional associations in Japan.

Some Other Pertinent Areas

The bilingual policy in the Philippines provides for the teaching of mathematics in English from Grade 1 through secondary school. However, the Division of City Schools, Manila, has undertaken a study in selected elementary schools to determine the feasibility of using the national language at least in the lower elementary schools.

In Singapore, much work has been done in providing different courses for students of varying abilities. Special courses are being developed for students in particular regions of Socialist Republic of Viet Nam to match the requirements of each region.

Courses for less able students are available in New Zealand, and in Singapore several special programmes have been introduced in elementary schools.

Contests and competitions and other special enrichment activities exist in Australia, China, Indonesia, New Zealand, the Philippines, and Socialist Republic of Viet Nam for students showing mathematical talent. A special project to assist gifted children is to be set up in Singapore in 1984. Special schools and special classes for high ability students exist in the Philippines and Socialist Republic of Viet Nam. In Thailand, work cards have been produced to meet the needs of talented and low ability students respectively. In Bangladesh, there is a scholarship examination for gifted children in Grades 5 and 8.

Chapter IV

SUGGESTIONS FOR IMPROVING SCHOOL MATHEMATICS EDUCATION

In this chapter, suggestions are offered for possible directions of future developments in the broad areas of curriculm content and methodology, resources for teaching and learning, teacher education, assessment of learning outcomes, research and other matters. These topics are based on the problems identified by countries, summarized in Chapter II, and discussed by participants in the light of innovations in their countries.

Curriculum Content and Methodology

All countries have been involved in curriculum change and development to varying extents over the past two or three decades. Many of the most prominent features of curriculum development in mathematics have been those associated with "new mathematics", a movement which appeared internationally in the late 1950s and early 1960s.

The use of the term "new mathematics" is now inappropriate and unhelpful. Mathematics, both as a discipline and as a school subject, is continuously developing. Many changes to mathematics curricula which have occurred in recent years have gone further than the innovations of the early 1960s, for example, the move to metrication of quantities in some countries, or the use of calculators and computers in mathematics teaching and learning. "New mathematics" is thus not only a misnomer, but it also sometimes has come to have deprecatory connotations in some countries. Further, the term has tended to be associated only with changes in content in the past, and has neglected an equally important component of curriculum, namely, the approaches and methods of teaching.

Content of the Curriculum

In deciding which topics to include in a mathematics curriculum, a number of criteria are relevant. These include the following:

The content should:

(1) be consistent with the aims for mathematics education for the country;
(2) be related to the socio-economic life and development of the country;
(3) be appropriate to the stage of cognitive development of the learner;
(4) be within the capability of the teacher to handle it competently and effectively;
(5) increase the student's awareness of the role and importance of mathematics in everyday life; and
(6) provide a foundation for the further study of mathematics and other subjects.

Broadly speaking, the content of the mathematics curriculum of any country is most likely to assist the development of the skills of computation, measurement, problem-solving, estimation and approximation, organization and interpretation of data, and of quantitative communication.

In particular, the following comments are offered on certain topics which were considered by the Workshop participants to be matters for possible debate.

The idea of *sets* should be used at all levels principally as a language for teaching mathematical concepts. It is not desirable for sets to be taught as an isolated topic in its own right. For this reason, properties of operations on sets, the theory of sets, and excessive use of the notation of sets should not be included in the school curriculum. On the other hand, set concepts in diagrammatic or pictorial form, used as a basis for sorting and developing ideas about correspondence and relations, are helpful in developing pupil's understanding.

The topic of *numeration system* in bases other than ten does not appear to have achieved its anticipated aim of illuminating and enhancing understanding of base ten systems and place value. Too frequently it has been taught as an end in itself.

The properties of the *real number system* are useful in helping children understand number relations. However, the terminology and formal expression of the properties have added nothing to this understanding and should be omitted from the mathematics curriculum.

Skills of *estimation and approximation* are of vital importance and should be strongly emphasized in any mathematics programme. With the increasing use of calculators, these skills are becoming more important. Students should be able to make sensible estimations and approximations and need to accept responsibility for judging the reasonableness of their answers. On occasions, an estimate will be sufficient without the need for an exact or highly accurate answer. To develop these abilities, students must have, among other things, a sound command of basic number facts and relations, and a thorough understanding of place value.

It is noted that there is a case for extending the study of the measurement of *time* to include the use of digital clocks. There are implications in the gradual replacement of analogue clockfaces (based on geometric concepts) with digital displays (based on arithmetic) which may have a bearing on the ability of pupils to

measure time intervals.

With the universal use of decimalized currency and a very wide adoption of metric measures, operations with *commom fractions* are likely to have less relevance to the mathematical needs of students in the future. The range of denominators used is already very limited and operations with mixed numbers are seldom if ever met in practice. The remaining argument for the retention of work on operations with fractions in the curriculum is that it prepares students for algebra or probability. In these cases, the introduction of the topic can conveniently be delayed. In general, then, a greatly reduced emphasis on the teaching of fractions is suggested.

The concept of *function* is useful in mathematics teaching at many levels. However, this usefulness is greatly lessened if too heavy an emphasis is given to notation or if the topic is treated too formally.

Statistics is of ever-increasing importance in today's world. At school level, curricula should stress descriptive statistics and should include practical activities rather than theoretical aspects.

As a topic, *probability* is more suited to secondary than to elementary schools. A certain maturity is required before an approach which extends beyond the informal and intuitive can be considered.

Methodology

The aims of mathematics education are likely to be served more successfully by a consideration of the methodology of teaching and learning, rather than by a concern over which content topics to include or not include in the curriculum. Curriculum statements and guidelines should therefore give attention to the methods and approaches by which the learning objectives of the curriculum might appropriately be achieved.

Any analysis of methodology should go beyond a discussion of chalk-and-talk or activity-based lessons to an examination of ways of fostering, for example, problem-solving abilities. In an era of ever-expanding knowledge, it is important for students to acquire the ability of "learning to learn". In the pursuit of this aim, the teacher is more likely to be a "guide on the side" than a "sage on the stage". In functioning in this supportive rather than directive way, the teacher has an important and crucial role in the mathematics classroom.

There is no single best method for teaching all pupils or all mathematics; each student has an individually preferred learning style. It is suggested that students be exposed in their mathematical education to a wide variety of teaching and learning methods and approaches. Further, teachers should make every effort to keep pace with technological developments and employ whatever learning devices are available, including calculators and computers.

The importance of understanding is affirmed. However, it is necessary in a teaching programme to establish a proper balance between "instrumental

understanding" (which answers the question "how to") and "relational understanding" (which enables the learner to answer the question "why").

Problem Solving

It is clear that the term "problem" has a variety of meanings. These include:

(1) Exercises where mathematical elements and operations must be abstracted from a language setting ("word problems");
(2) Real or artificial applications of mathematics;
(3) Structured or "closed" problems presented by another person; and
(4) "Open" problems which require formulation by the solver.

The essence of any true problem is that it involves a novel situation to the solver, that is, a set of circumstances which have not been previously encountered and where the process of solution is not immediately recognizable.

Problem solving should be incorporated into the curriculum as a fundamental aim of mathematics education. The most important reason for promoting problem solving is to develop the student's ability to acquire knowledge independently, that is, to encourage autonomy of learning. This is especially important in a climate where there is more content competing for inclusion in the total school curriculum than there is time available to deal with it.

Manipulative and computational skills and other techniques are necessary as a background to problem solving. Problem solving does not take place in a vacuum. However, it is too often the case that students receive too much emphasis on skills and techniques, compared with the time given to solving open-ended problems. Time is needed for problem solving, especially to provide opportunities to reflect on the general strategies employed, to identify and share with the class the variety of ways by which students have solved a particular problem. It is essential that individual pupils have ample opportunity to talk about the methods of solution they have selected for their problems.

It was thought that some of the time could be made available by using calculators to take care of computational work, or by reducing time spent teaching fractions or extended arithmetical algorithms. There is perhaps a need to look dispassionately at the mathematics curriculum to see what can be removed; people usually feel most attached to familiar topics. A further suggestion for making time available in present programmes for the purpose of problem solving is through the integration of mathematics with other subject. Indeed, problem solving across two or more subjects has much merit.

In some countries where teachers are inclined by tradition and training to provide type-examples and standard algorithms to be practised, there may be difficulty in encouraging problem solving behaviours. There are, therefore, major implications for both pre- and in-service teacher training.

In teaching problem solving, some attention needs to be given to problem finding and formulation, where the student is encouraged to find or develop

problems to be solved by the rest of the class. Participants discussed on the respective merits of small-group, whole class or individual methods.

In this regard, it is suggested that a regional workshop should be organized to prepare guidelines for teacher training activities to promote problem solving methods in mathematics teaching and to assemble relevant support materials.

Links between Mathematics and Other Subjects

Because the elementary school teacher typically teaches pupils for all or most of the general curriculum, there can be natural links between mathematics and other subjects at this level. Nevertheless, there is concern in some countries that the teaching methods used for language and social studies are different from those used for mathematics, and that opportunities are sometimes missed for applying mathematics in other subjects. There is a particularly important link between mathematics and language.

At the secondary level, teachers tend to specialize and it is frequently found that there are problems because, for example, the science teacher uses different notation, different terms, and methods different from those used in mathematics. Similarly, the mathematics teacher may not appreciate the mathematical requirements of science. Ways of overcoming this two-way communication gap must be found, by providing time for the mathematics teacher to consult with teachers of all other subjects on a regular and continuing basis. One country reported a highly successful small scale team-teaching project across mathematics, science and language which resulted in benefit for all concerned, teachers and students. The involvement of teachers of other subjects in mathematics curriculum formulation is also suggested.

Technical and Vocational Training

The most satisfactory preparation in mathematics which can be provided at school for later technical and vocational training is a sound general mathematical education.

Specific mathematical requirements of technical and vocational training courses should be met within those specialist courses, although this does not preclude particular topics being anticipated in general courses at secondary school. These may be used as examples of practical applications and serve to motivate the learning of mathematics in secondary school for students with the corresponding interests. An analysis of the mathematics required in technical and vocational courses may suggest common elements which can profitably be included in the secondary school curriculum and provide suitable links between the courses.

Generally speaking, specialization in mathematics should be deferred until the penultimate grades of secondary school.

Calculators and Computers

The present situation regarding *calculators* varies from country to country. In a few countries in the region, calculators have been accepted and incorporated into teaching programmes at some levels. In some countries there is a hesitancy to do so, and in others a policy has either not yet been considered, or there is official rejection of the device as far as school mathematics is concerned.

The use of calculators in mathematics in the future will be unavoidable. Already, students in many countries use calculators out of school, perhaps more than their teachers realize. Calculators are also an established tool in the business and commercial environment. In advocating a wider acceptance of calculators in schools, however, the Workshop recognizes the costs involved may be a serious impediment for some countries at this stage.

Calculators have two main uses in mathematics. Firstly, by lightening the student's computational load, calculators allow greater attention to be directed to the underlying mathematical ideas. For example, in trigonometry, students need no longer be distracted by burdensome calculations and can concentrate on understanding and applying the trigonometrical relations themselves.

The use of calculators in this way has many and major implications for the mathematics curriculum. It may no longer be appropriate to include some computational algorithms such as those for "long division" and "long multiplication" in a mathematics course unless convincing educational reasons for their retention can be advanced. Other skills may require adjustment in the grade level at which they are taught; with a calculator, six-digit calculations are no more difficult than those with two digits. Some concepts and skills must receive greater attention, for example, place value and decimal concepts, knowledge and recall of basic facts, skills of rounding, and of estimation. Mental methods may also become more useful. If calculators are accepted, there will be little practical value in continuing to teach the use of logarithm tables and slide rule for calculation.

The second use of calculators is as aid to create and explore new learning situations. For example, number patterns and properties can be investigated at all levels by means of a calculator, or the characteristics of exponential growth functions can be studied.

Concerning *computers*, the Workshop believes that the study of computers, computer programming, applications of the technology and social implications of its use do not belong of themselves in a mathematics curriculum and should be taught as a separate subject.

However, it is important to distinguish between learning about computers and using computers in mathematics. Computers can be used to advantage in mathematics in several ways. The power of computers to process data rapidly and to display results graphically permit them to be used as tools, for example, in analyzing and presenting statistical data, in studying convergence of series, in solving equations, in differentiating or integrating in cases where analytic methods

are not available, and so on.

The computer can also be a means by which students can explore mathematical ideas and principles, for example, the characteristics of graphs of algebraic or trigonometric functions for varying values of the parameters, or to simulate situations involving probabilities through the use of random number generators. These uses are in harmony with the objectives of mathematical education in the way in which they foster mathematical creativity and encourage students to inquire.

A further use of computers in mathematics is through the use of Computer Assisted Instruction (CAI). This may be a helpful and cost-effective method of dealing with some individual learning difficulties in mathematics and in teaching certain skills. There is a need, however, to monitor research on the long term effects of CAI.

There is a need to create an opportunity for countries to share experiences in the use of calculators and computers in teaching mathematics, to study the likely impact of these technologies on mathematics curricula of the future, and to prepare guidelines to assist countries which are reviewing their curricula to take account of these technologies.

Geometry

Geometry is an important component of mathematics at all levels. The following are among the reasons for including geometry in the mathematics curricula of schools:

(1) It stimulates the development of spatial perception;

(2) It provides for the acquisition of knowledge of properties of geometric figures, many of which have practical use;

(3) It fosters the development of geometric reasoning, both inductive and deductive; and

(4) It promotes the use of inquiry method and the use of geometrical techniques in problem solving.

Most countries agree that geometry in elementary schools should be informal, descriptive and exploratory. It should cover simple properties of two and three dimensional figures found in the pupil's environment. Practical methods, activities and constructions should predominate.

However, there is uncertainty as to the way geometry should be approached in secondary schools. This uncertainty is evident in the variety of approaches and trends in the teaching of geometry in countries represented at the Workshop. Formerly, most countries favoured a deductively organized approach which stressed proof and a logical sequence of theorems sometimes including a set of axioms as foundations. Some countries have retained this approach.

In other countries, a lack of success with this approach in the case of students of average or below-average ability encouraged the introduction of a less formal

treatment through transformations.

This had the added appeal in the early years of "new mathematics" of permitting links to be made to other parts of mathematics through sets, matrices, vectors, algebraic structure, and so on.

Possibly because of inadequate levels of teacher training to familiarize teachers with the objective and rationale of this approach, or for other deeper reasons, there has been a partial retreat from an approach based entirely on transformations in some countries. In some cases, a factor which has stimulated this move has been the feeling that transformation geometry does not facilitate the learning of methods of proof in mathematics. This is considered by some to be a deficiency, especially in the case of students expected to proceed to university. The question is, if proof is not taught in a geometry course, where else can it be learnt?

Many countries have attempted to resolve the dilemma of how best to teach geometry by employing a combination of approaches to geometry. This lack of consistency and coherence is often a source of unease to mathematics educators in the countries concerned.

A detailed study of the state of geometry teaching and its place in the mathematics curricula of the region should be made in order to clarify objectives and suggest possible approaches to meet the geometrical needs of students of differing abilities in the countries of the region.

Learning Resources

A variety of resources should be used in the teaching and learning of mathematics in order to achieve better outcomes. However, it is realized that textbooks still constitute the main resource for teaching and learning now and will do so in the foreseeable future, particularly at the secondary level. Like the curricula, textbooks are centrally controlled at all levels in all of the countries but one, in so far as content is concerned.

A system of centrally controlled textbooks has several advantages. Firstly, such control ensures quality and some uniformity in the treatment of content in all schools. Secondly, it also ensures a match between the stated objectives and the instructional content. Besides being relatively cheaper to produce, centrally controlled textbooks also make teacher development programmes easier.

On the other hand, a system of centrally controlled textbooks also has disadvantages. It either reduces local initiative in undertaking innovations, or limits the participation of other individuals or groups concerned. It may also reduce teacher responsibility and commitment to a minimum. In most cases, the number of textbooks is limited and furthermore, since textbooks have to be used for a reasonable period of time in order for the government to get a return on its investment, schools and teachers do not have a choice within that specified period. In cases where textbooks are also printed centrally, the lower cost of production

may be offset by the cost of distribution throughout the country.

On the whole, the Workshop felt that the use of textbooks has been dominating the teaching and learning of mathematics. It is suggested that steps be taken to encourage teachers to use more widely other learning resources such as guide manuals, workbooks, overhead projectors, films and slides, educational programmes on television and radio, human resources other than the teachers, etc.

Besides accepting the need to use these resources, teachers should also be exposed to the mechanics of preparation and effective utilization of those resources in the classroom. This can be done through workshops and seminars for trained teachers as well as by giving due emphasis to the matter in the pre-service education of teachers. Demonstration lessons using these resources should also be organized or televized for teachers from time to time. Authorities concerned should encourage teachers to use such resources wherever available.

Teacher Education

The ultimate success of any classroom learning situation depends crucially on the effectiveness of the teacher. It is the teachers who provide the important link between the students and the curriculum. To be effective in the teaching of mathematics, it is not sufficient for mathematics teachers to know only the subject matter itself. They also need to know their students. More than that, they need to know the mental development of the students, along with the ways in which they acquire mathematical concepts. Apart from this, they need to know the strategies of teaching mathematics and the methods of teaching specific topics as well. There is also the need for them to know how to develop their own resources and to use any other resources in their teaching to further enhance learning. The ability to organize and operate a mathematics workroom would be another requirement on the part of a mathematics teacher.

While preparing teachers to be effective in their teaching for the immediate future, they should also be prepared for changing needs in the long term. This may also orient the teachers towards innovation and enable them to adapt to change.

To prepare teachers to meet present and future needs, the pre-service teacher education curriculum ought to include the following areas of study:

(1) Objectives of mathematics education;
(2) Mathematical content;
(3) Teaching methods and strategies;
(4) Evaluation;
(5) Psychology, with particular reference to mathematics learning;
(6) Classroom management, including management of workrooms;
(7) Improvisation/preparation/utilization of learning resources;
(8) Curriculum development; and
(9) Research skills.

However, it is realized that in pre-service teacher education, many of these areas are to be dealt with. Nevertheless, there are tendencies that these areas are dealt with separately, and it is difficult for student teachers to gain a full understanding of the relevance and importance of these areas in the teaching mathematics. In such a situation, student teachers very often are required to exercise "transfer of knowledge" by themselves. To allow the mathematics curriculum for pre-service education to be more explicit for the student teachers concerned, it is suggested that the areas of studies mentioned above could be organized into three categories:

(1) *Core*; covering areas pertaining to objectives of mathematics education, content, teaching methods and strategies, and evaluation;

(2) *Supportive*; covering areas pertaining to psychology, classroom management and improvisation/preparation/utilization of learning resources; and

(3) *Supplementary*; covering areas pertaining to curriculum development and research skills.

These divisions are not meant to indicate equal commitments of time. In general, it is expected that, as the name suggests, most attention will be given to the core. The supportive areas will relate directly and explicitly to the core, and the supplementary areas will aim to extend the range of knowledge and skills beyond classroom teaching. Particular attention would also be given to readiness to retrain and adapt to unknown future needs.

On teaching methods and strategies, the Workshop felt strongly that these should be demonstrated and practised deliberately by those responsible for pre-service education.

There is also the need to look into the balance between the supply and the quality of mathematics teachers. In some countries more teachers are required to meet the increasing number of pupils, especially with the urgency of universalizing education at the lower levels. However, at the same time, it is also necessary to maintain quality in the teaching profession. This is to ensure that the mathematics programmes in schools are uniformly implemented for the whole school population.

In this context, student teachers who would be required to teach this subject later on, would have to possess a minimum qualification in mathematics at the time of their intake. This would allow further improvement in terms of the depth and coverage of the pre-service programme mentioned earlier.

For those teachers who are already teaching, but who lack mathematics qualifications due to previous circumstances, follow-up teacher education programmes should be organized to upgrade and update their knowledge, skills and attitude. It is suggested that resource centres be set up to enable teachers to meet and discuss professional matters and obtain the services of a consultant in mathematics teaching and learning. At the secondary school level, a head of department or coordinator for mathematics in the school can provide leadership

through regular meetings and discussions. Teacher associations should also play a more significant role in promoting professional growth among their members.

Due to the financial constraints in most countries on funds for in-service education of teachers, it is suggested that the feasibility of distance-learning programmes for serving teachers be studied.

The perceived status of teachers seems to be a significant factor which critically affects supply and demand in some countries. It may be necessary to improve the situation in order to attract more people into the profession and prevent the drain of qualified personnel.

In some countries, coordination among the various organizations responsible for providing teacher development programmes could be improved. These organizations also need to show a readiness to adapt to meet changing needs in mathematics education. In turn, teachers should realize the need for a mathematics curriculum to be in step with the changes taking place in their country.

In addition to the need to provide for personal development in teacher education programmes, the following were suggested by the Workshop:

(1) Seminars and workshops on developments which have relevance to the curriculum could be organized at regular intervals;

(2) Forums and discussions on similar topics as above could be broadcast through TV or radio, or published in newspapers to enable the public in general and teachers in particular, to become informed;

(3) Field trips to various business establishments and industries could be organized for teachers; and

(4) The development of an association of mathematics teachers, which may be a formal society or only an informal network, to provide a forum for demonstration, discussion and sharing of ideas could be encouraged.

Assessment

Assessment is an important component of the educational system. In the case of mathematics, in particular at the elementary level, it has been geared towards criterion-referenced tests in some countries while in others norm-referenced tests are still used. The main focus of classroom assessment should be formative to provide feedback on the progress of students and insight into their learning problems for the purpose of improving achievement. Also, assessment should focus on the attainment of other set objectives of mathematics education. It is also recommended that assessment be conducted using various forms such as observations, interviews, as well as paper and pencil tests. In general, assessment of student's learning must be geared towards ensuring the attainment of all aspects of mathematical education.

It is realized that external examinations for the purpose of selection or certification have very strong influences on the curriculum. In cases where these

examinations are unavoidable, it is suggested that due consideration must be given to validity in relation to the set objectives. New approaches to identifying the desired groups of students for selection purposes have to be identified by means of which it may be possible to offset the negative influences of external examinations on the curriculum.

Towards improving the quality of classrom assessment, schools should set up panels to select items, develop checklists or prepare tests. Steps should also be taken by authorities concerned to develop item specifications or item banks to aid teachers.

Research

At present there is not enough research being done into mathematics education among countries of the region. Where research is done, it is mostly of the traditional type, conducted as part of university post-graduate requirements. This type of research is not often readily applicable to the classroom. Research conducted by Ministries of Education is generally directed towards demographic studies, surveys and validation of pilot projects, and as such it is necessary. However, action-oriented developmental research is also required to meet the pressing needs of mathematics education in the region. The dearth of this kind of useful research is due, among other things, to a shortage of personnel with the requisite skills, and to inadequate financial support for research.

Forward-looking research is essential for making curricular decisions and curricular choices. Countries of the region are facing new problems as they approach a state of universal education in the face of, for some, a severe shortage of qualified and trained teachers, and possible problems of motivation, socialization, and so on, on the part of pupils. Instead of being based on today's conditions or the past experience of today's teachers, mathematics curricula of the future must be attuned to the environment of the future and take into account the new demands and responsibilities of a world as yet not fully foreseeable. This is the background against which most countries must initiate research.

Research is initially expensive, but it is important that it be seen as an investment. Ad hoc decision-making on curricular issues, too common in most countries, can lead to costly mistakes and unnecessary expenditure at a later stage. Infact, there is evidence that this has already occurred in some countries in adopting foreign materials.

There is a need for research into fundamental aspects of curriculum development such as the choice of content and its organization. Usually, experimental work will be needed before new programmes are introduced.

Research is also needed for the development of effective classroom practices. Teachers need to have a better understanding of children's difficulties with different mathematical concepts (including terms and symbols), children's styles of

learning, the effectiveness of learning resources and also the effectiveness of the teaching methods they use.

Research of this nature should involve teachers themselves as researchers. This will help ensure that the research will be useful and that it focusses on real needs and problems in classroom. Teachers may require support in designing their studies and in carrying them out. Training in elementary research skills and how to interpret research findings should, where possible, be included in professional training programmes of teachers. The involvement of teachers in research should lead to more effective application of the findings in the classroom.

Other areas for research include the problems of socially, economically or geographically disadvantaged children in learning mathematics, the effects of cultural differences and varying technological environments.

Research needs to be coordinated and should take entire findings into account. Before undertaking a piece of research, it is essential to first make a careful study of previous research within the country as well as elsewhere. Expenditure in time and money can be reduced by learning from and building upon previous work. Although findings from foreign countries may not apply to local conditions, these findings may suggest effective ways of designing and conducting the studies. In general, studies which replicate another country's research should be of up-to-date research. At the same time, original local research will also be needed. In the final analysis, each country must solve its problems in its own way, using indigenous cultural elements where possible and at the same time adopting ideas judiciously from other countries where appropriate.

There is a need to coordinate research work within countries as well as among countries to help prevent unnecessary repetition. Countries can also learn from one another's experience. A national organization, either a formal one (e. g., National Institute for Educational Research in Japan) or an association (e.g., Mathematics Education Research Group in Australia) can help to coordinate research and disseminate findings. There is also a need to share internationally or regionally the results of research and the emerging questions for which further research is required. A centre or clearing house, to serve a particular country or a region, with an efficient storage and retrieval system and links to other such systems, is a prerequisite for a sound research programme to serve the region's countries.

Research findings, particularly those relating to classroom practice, need to be widely disseminated among teachers through professional journals, newsletters, or occasional papers. This means that the research findings have to be put into a concise form and in lay terms so that they can be readily digested and understood by teachers and especially by decision-makers at all levels of the education system. Currently, much research is published in highly technical language which teachers have difficulty in understanding and may easily misinterpret. There is a need to train a cadre of professional workers who can translate findings given in technical

language into lay person's language without distorting the findings. The probability of accidental or deliberate misinterpretation must be minimized. These professional workers can also suggest ways in which a teacher may apply the research findings in practice.

Research findings can also be disseminated through regular regional or national forums where reports can be shared and discussed, and further needs identified.

Some Other Pertinent Areas

Language

There are three aspects to the problem of language:

(1) Mathematical language;
(2) Language used as the medium of instruction; and
(3) Mother tongue.

Certain countries teach mathematics even to the children in lower elementary classes in a language other than their mother tongue. There was general agreement among the participants that at least in the lower elementary classes, mathematics should be taught in the mother tongue.

Mathematical terminology and symbolism are important aspects of mathematical language. It was agreed that mathematical terminology and symbolism should not be introduced to children until the need arises. Children should be able to understand their meaning of these before they are applied in teaching. Once a term or a symbol has been introduced, the teacher should use it in a meaningful way and the children should be encouraged to use it wherever applicable. At the elementary school level, if mathematics education is given in a language other than the mother tongue, every effort must be made to give further explanation to the children in their mother tongue if what is intended is not grasped by them.

Many countries have problems in teaching mathematics in their national language. Since most of these languages are undergoing development, the time is yet to come for a full list of mathematical terminology to be available. Each country must tackle this problem of mathematical vocabulary in the national languages in its own way.

Needs of Special Groups

It is generally felt that the education system in each country should make provision to cater for the needs of the following special groups:

(1) Socially, economically or geographically disadvantaged children;
(2) Slow learners; and
(3) Talented or gifted children.

It must be borne in mind that there is a wide range both in the ability to learn

mathematics and in the attitude of learning mathematics among students of the same age or in the same class. It is also realized that some of the difficulties of slow learners in mathematics are due to language.

The Workshop suggests that:

- Special programmes and specially trained teachers be provided within the school to give slow learners whatever assistance and guidance is necessary;
- Teachers should be trained to deal with slow learners and mixed ability groups;
- Differentiated materials should be developed;
- Programmes for slow learners should provide for the motivation of students and be relevant to reality;
- Electronic calculators may be used as a tool for computation to ease anxiety in mathematics;
- Computers may offer enrichment opportunities for gifted children;
- CAI may be a good learning resource for slow learners; and
- Accelerated promotion and early entrance to university may be considered for the highly talented.

The following strategies are also suggested for consideration by individual countries:

- The provision of a specially trained resource teacher who works alongside the classroom teacher during mathematics lessons, or who may withdraw some students from time to time for special assistance;
- Where the teacher teaches all subjects, some groups of pupils may receive special assistance in mathematics while the others work in other subjects which may not require intensive teacher involvement;
- Parallel timetabling for mathematics across other classes in the same or other grades so that students may progress at their own pace;
- The provision of resources and activities for enrichment for gifted students so that acceleration is minimized;
- The establishment of special classes or schools for gifted students;
- The use of talented students as peer teachers to assist less able students;
- The introduction of special programmes during extended school hours on a voluntary basis.

The Workshop further suggests that mathematics programmes for talented or gifted children should emphasize problem-solving and other higher level activities. They should be encouraged to do independent work in the form of projects by freeing them from normal lesson commitments. Some ways to foster mathematical talent may be:

- Mathematics camps;
- Mathematics contests or scholarship examinations;
- Mathematics clubs and enrichment programmes;

- Special talks or short courses (1 to 2 weeks) conducted by university staff;
- Joint programmes by neighbouring schools.

Suggestions for Regional Cooperation

While searching new directions for mathematics education, the Workshop suggested some areas for regional cooperation and the main suggestions were summarized here for convenience as follows:

(1) To encourage and facilitate the inclusion of *problem solving method* in mathematics curriculum of the region, a workshop should be organized to outline an appropriate programme for teacher training. The Workshop would also prepare a range of relevant support materials including a collection of problems suitable for use in the region. (See *pp* 40 and 41)

(2) There is a need to create an opportunity for countries in the region to share experience in the use of *calculators and computers* in teaching mathematics, to study the likely impact of these technologies on mathematics curriculum of the future, and to prepare guidelines to assist countries to take account of these technologies when reviewing their curricula. (See *pp* 42 and 43)

(3) A detailed study of the state of *geometry teaching* and its place in the mathematics curricula of the region should be made in order to clarify objectives and to suggest possible approaches to meet the geometrical needs of pupils of different abilities in the countries of the region. (See *pp* 43 and 44)

(4) In order to encourage the use of a wider range of *learning resources* in mathematics classrooms there is a need to provide advice and assistance for teachers on the construction of low-cost materials suitable for mathematics teaching in schools of the region. This advice should include techniques of using these materials as well as environmental materials and other media and resources to facilitate mathematics teaching. (See *pp* 44 and 45)

(5) Guidelines should be prepared for effective *teacher education* and development programmes, especially for those countries faced with a rapidly increasing school population and a shortage of well qualified mathematics teachers. These programmes would cover both pre- and in-service training and would employ a variety of methods, resources and technologies. In the first instance, the guidelines should be directed towards elementary school teacher training. (See *pp* 45 to 47)

(6) To coordinate *research activities* among countries of the region a centre or clearinghouse should be established. This would facilitate the exchange of research findings, help prevent unnecessary repetition and

be a source of information about previous, current and related research. (See *pp* 48 to 50)

Annex I

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Annex II

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Annex III

1983 ICMI-JSME REGIONAL CONFERENCE ON MATHEMATICAL EDUCATION

Participants in the Workshop were very pleased to be invited to attend the 1983 ICMI-JSME Regional Conference on Mathematical Education and expressed their appreciation for this unique opportunity and for the assistance from the organizers which made their involvement possible.

All were impressed by the structure and excellent organization of the conference in catering for about 400 participants from 27 countries.

A common difficulty faced by participants was the choice of two subplenary sessions from 7, and 9 working group sessions from 46. The range of topics was very wide and appealing. The Programme and Abstracts booklet was very helpful in guiding participants in their choice and was appreciated. Participants were also pleased to have copies in English of those papers delivered in Japanese. Participants are looking forward to receiving a copy of the Proceedings of the Conference in due course to enable them to read in greater detail and to think further about topics discussed in sessions they attended, as well as to learn about others they were unable to attend.

Most considered that the value of the conference was increased by their involvement in the Workshop for the previous two weeks, in that they were able to view aspects of mathematics education from an international perspective. In general, the conference and the Workshop were mutually supportive experiences.

Many papers and discussions during the conference dealt with issues from a global point of view and this helped participants to reflect on Workshop discussions. Several speakers at the conference stressed the fact that meetings such as ICMI-JSME Conference do not attempt to provide solutions to problems and issues but instead provide a forum at which problems can be identified and clarified. Views on possible strategies for their solution can be shared. However, Workshop participants reiterated their belief that each country must solve its problems in its own way, learning what it can from the experience of other countries with similar problems.

For participants, exposure to the views of eminent mathematics educators on

the present state and trends in mathematics education on the international scene was especially useful and complemented the Workshop discussions of the previous two weeks. The global problems categorized by Professor Christiansen were very relevant in this respect. The conference provided opportunities for consultation and interaction which are not possible to obtain from books or journals.

Participants were of the opinion that ICMI-JSME Conference tended to present the view of developed countries, with a few exceptions. For example, in many countries of the region, there is a large non-urban population. The matter of different approaches for such distinct groups dose not arise in developed countries because of their homogeneity and was seldom discussed at the conference. For other countries, however, matters such as this are vital. One speaker whose contribution was memorable in this regard was Father Nebres, who paid specific attention to problems of developing countries. His analysis of issues into macro-problems (dealing with the economy, politics, language, and culture of a country) and micro-problems (curriculum, teacher training, textbooks, calculators, etc.) was especially noteworthy. Clearly, macro-problems demand time and energy for their solution in developing countries, whereas the developed countries can afford to give greater attention to micro-problems, having largely solved the macro-problems. Nevertheless, these latter countries are perhaps at risk in neglecting global aspects of mathematics education as a consequence of concentrating on micro-problems.

It was noted, however, that most of the presentations at the conference were forward-looking and had implications for all countries, developed or developing.

A major theme of the conference concerned the use of new technologies in mathematics education. The effect of macro system factors on the availability in schools of calculators and computers, taken in conjunction with the unresolved problems of developed countries on how and when to make best use of these devices in mathematics teaching and learning, poses a major problem for developing countries. A suggestion for cooperative action in designing and producing calculators specifically for educational use and thereby to take advantage of mass market economies was noted. Discussions on calculators and computers tended to focus on secondary rather than elementary schools. As far as computers are concerned, the emphasis was on Computer Assisted Instruction, and exploratory investigative uses were not often mentioned. Little consideration seemed to be given to means of developing and sharing educational software, nor to the substantial matter of training teachers to use computers effectively in the classroom. Participants agreed that local experimentation in use of calculators and computers must take place in order to plan for the future, and that this work should include a cautious interpretation of the experiences of other countries.

Deliberately, ICMI-JSME Conference did not include a separate section on teacher education. However, participants observed that the topic arose spontaneously in most discussions, and noted that this underlined and reinforced their belief that the classroom teacher has a central and crucial role in the

educative process. The teacher is the agent of change at the most fundamental level, and all facets of teacher education must be carefully planned and accomplished if real change is to be achieved.

Another theme of the conference concerned problem solving. It was observed that a great range of approaches were being followed in an effort to increase the emphasis given to problem solving and other higher thinking skills in mathematics curricula. It is clear that there is a major challenge to incorporate problem solving successfully into mathematics programmes, particularly in encouraging teachers to accept this as a vital objective, and in improving educators' understanding of the process itself.

As a generalization, participants considered that mathematics as discussed at the conference tended to be confined to "pure" mathematics and neglected mathematics in the real world. For example, problem solving was based on situations arising within mathematics rather than on applications of mathematics in the students' environment.

Many research projects and studies were reported at the conference. Most were based in Japan and some involved collaboration between school teachers and university researchers. The conference confirmed and strengthened the wish of the Workshop participants to provide a mechanism for the exchange and sharing of research findings and efforts. Participants agreed that classroom research by teachers is especially fruitful because it originates from problems identified by teachers. In this type of action-oriented research, changes in methods and attitudes towards mathematics teaching of the teachers concerned are probably more important than the dissemination of results.

Generally speaking, more attention was given by speakers at the conference to secondary than to elementary education. Nevertheless, the conference as a whole helped to strengthen links between elementary, secondary and tertiary levels by bringing people from each level together. Little was said at the conference about teaching methods, and especially about the problem of dealing with individual difference in mathematics and the matter of teaching students how to learn for themselves.

Participants considered they have learnt much about mathematics education in Japan from the conference and from the visit to schools arranged as part of the conference. They admire the attitude in Japan of looking critically at progress and achievements with a view to effecting further improvements.

The conference as a whole, and especially the plenary paper by Professor Christiansen on "New Trends on Mathematics Education from a World-wide Viewpoint" served to remind participants of the great complexity of the process of mathematics education and of the enormous number of factors which must be taken into account in relation to "Mathematics Education for Changing Societies", the theme of the conference.